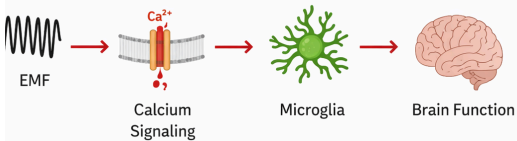


Electromagnetic Field-Induced Modulation of Microglial Calcium Signaling

Introduction

- Microglia continuously survey the CNS and rapidly respond to neuronal activity, ATP, injury, and other environmental changes.
- Intracellular Ca^{2+} signaling links extracellular cues to microglial behaviors including process motility, migration, and functional state.
- Electromagnetic fields (EMFs) can alter cellular signaling, but their effects on microglial Ca^{2+} dynamics in intact neural tissue remain poorly understood.
- We hypothesize that pulsed EMF exposure alters microglial Ca^{2+} signaling and associated cellular responses.



Methods

Two-photon Ca^{2+} imaging

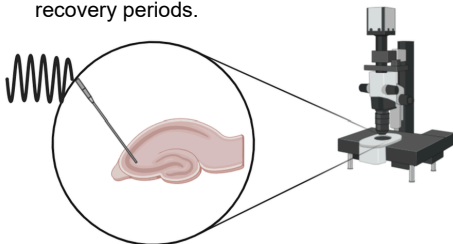
- Acute brain slices containing fluorescently labeled microglia are imaged to record changes in Ca^{2+} fluorescence.

Electrophysiology

- Local neuronal activity is recorded alongside imaging to relate neural activity to microglial Ca^{2+} responses.

EMF Stimulation

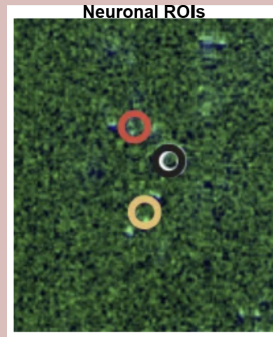
- Pulsed EMF is applied during exposure periods, and then compared to baseline and recovery periods.



Objective – Determine how pulsed electromagnetic stimulation alters microglial Ca^{2+} activity and motility in acute neural tissue

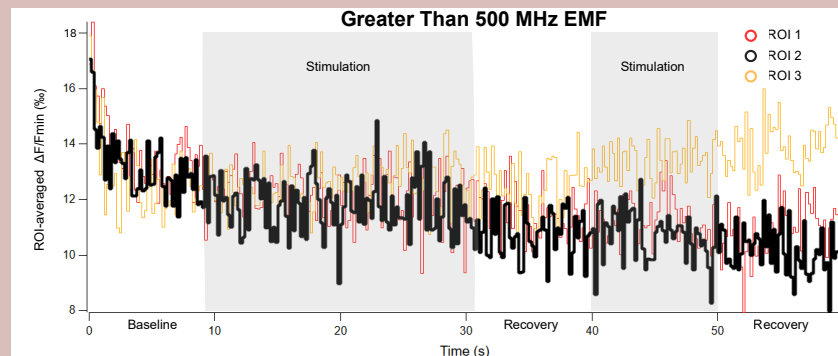
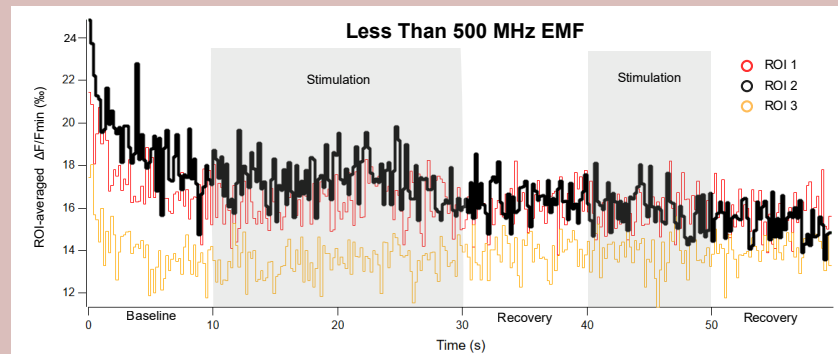
Results

Preliminary validation using hippocampal neuronal Ca^{2+} recordings



Preliminary observation: Hippocampal GAD2 inhibitory neuronal Ca^{2+} activity was recorded during two EMF stimulation periods. The higher-frequency condition appeared to show greater divergence among ROI responses, particularly during and after the second stimulation period.

These recordings establish the imaging/stimulation framework for subsequent microglial Ca^{2+} measurements alongside neuronal activity.



Discussion

- This project tests whether EMF alters the Ca^{2+} signaling microglia use to sense and respond to their environment.
- Combining two-photon imaging and electrophysiology links electromagnetic stimulation with neuronal activity and microglial response.
- This approach provides a framework for investigating EMF-driven changes in neuroimmune signaling.

Future Directions

Couple Ca^{2+} Imaging with Electrophysiology

- Determine whether changes in neuronal activity precede or accompany microglial Ca^{2+} responses.

Test HF-EMF Effects

- Compare microglial Ca^{2+} event frequency, amplitude, duration, and motility across baseline and electromagnetic field stimulation, and recovery.

Integrate Experimental Data with a Model

- Use measured Ca^{2+} and microglia response dynamics to build, constrain and validate a neuron–microglia computational model.

References

- Anthony D Umpierre-Lauren L BystronYanlu YingYong U LiuGregory WorrellLong-Jun Wu (2020) Microglial calcium signaling is attuned to neuronal activity in awake mice eLife 9:e5502.
- Eme-Scolan E, Dando SJ. Tools and Approaches for Studying Microglia In vivo. Front Immunol. 2020 Oct 7;11:583647. doi: 10.3389/fimmu.2020.583647. PMID: 33117395; PMCID: PMC7576994.
- Gomez-Nicola D, Perry VH. Microglial dynamics and role in the healthy and diseased brain: a paradigm of functional plasticity. Neuroscientist. 2015 Apr;21(2):169-84. doi: 10.1177/1073858414530512. Epub 2014 Apr 10. PMID: 24722525; PMCID: PMC4412879.
- Mendoza-Muniz V, Stojanovic M, Mulli DE, Agrawal DK. Microglial Response to Inflammatory Stimuli Under Electromagnetic Field Exposure. Arch Clin Biomed Res. 2025;9(4):304-315. doi: 10.26502/achb.50170467. Epub 2025 Jun 30. PMID: 40855885; PMCID: PMC12372985.
- Pachhapure S, Mufida A, Wei Q, Choi JS, Jiang BC. Mitigation of 3.5 GHz Electromagnetic Field-Induced BV2 Microglial Cytotoxicity by Polydeoxyribonucleotide. Curr Issues Mol Biol. 2025 May 22;47(6):386. doi: 10.3390/cimb47060386. PMID: 40699785; PMCID: PMC12192555.
- Vidal-Triguero A, Radford RAW, Aramdeh JA, Maurel C, Scherer NM, Don EK, Lee A, Chung RS, Graeber MB and Morsch M (2022) Microglia morphophysiological diversity and its implications for the CNS. Front. Immunol. 13:97786. doi: 10.3389/fimmu.2022.97786.
- Wang, Shasha, et al. "Roles of microglial calcium channels in neurodegenerative diseases." Human Brain, vol. 3, no. 1, 9 Apr. 2024, <https://doi.org/10.37819/hb.1.1806>.